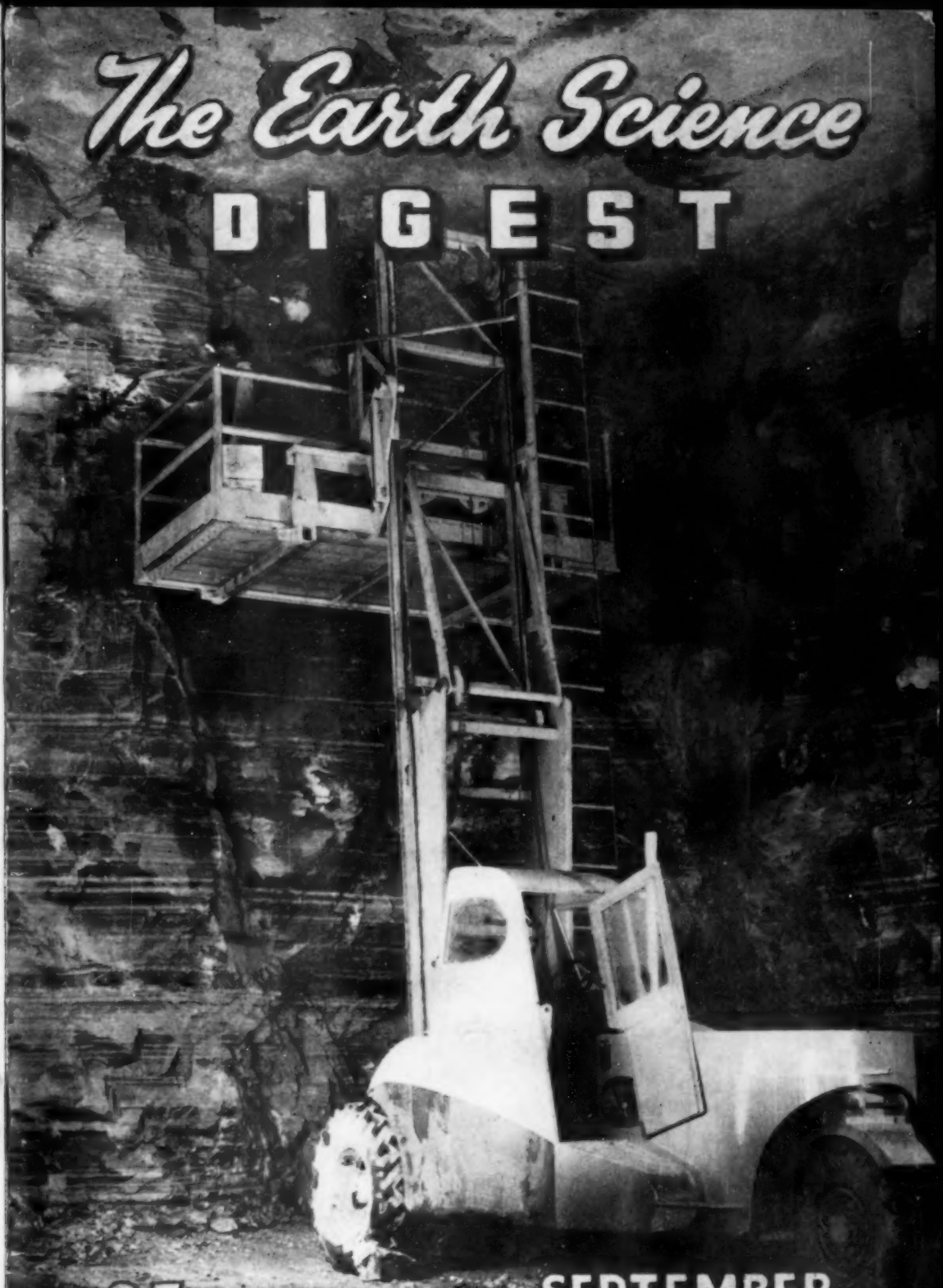
The Earth Science DIGEST



25¢

SEPTEMBER
1949

The Earth Science Digest

Revere, Massachusetts

Vol. IV SEPTEMBER, 1949 No. 2

A magazine devoted to the geological sciences.

THE EARTH SCIENCE DIGEST is open to articles of geologic interest. Manuscripts, photographs and sketches will be returned if accompanied by ample first-class postage.

Subscriptions: U. S. and possessions, Canada, Philippine Is., Latin America and Spain: 1 year, $2.00; 2 years, $3.75; 3 years, $5.00. Other countries: 1 year, $2.50. Single copies, 25 cents.

Special group subscription rates allowed to educational institutions and societies.

Published Monthly by The Earth Science Publishing Company, 77 Victoria St., Revere, Mass. Entered as second class matter April 12, 1948 at the post office at Boston, Massachusetts, under the Act of March 3, 1879.

S. ALBERT EISENBERG, Publisher

GERTRUDE ROBERTS, Business Manager

CONTENTS

Meetings and Conventions

New England Intercollegiate Geological Excursion. Oct. 14-16, 1949. Tufts College, Medford, Mass. Oct. 14; Squantum field trip (Squantum tillite), Prof. Robert Shrock, M.I.T., Leader. Oct. 15; Chelmsford field trip (Chelmsford granites and geology of the adjacent areas), Dr. L. W. Currier, U.S.G.S., Leader. North Shore field trip (shore line geomorphology, glacial geology, bedrock geology), Profs. Robert L. Nichols & Charles E. Stearns, Tufts College, Leaders. Oct. 16: Hingham field trip (bedrock geology), Prof. Marland P. Billings, Harvard University, Leader; Field trip to classic areas for shoreline and glacial geomorphology, Prof. Robert L. Nichols, Leader.

Geological Society of America, 62nd Annual Meeting; Paleontological Society, 41st Annual Meeting; Mineralogical Society of America, 30th

Annual Meeting; Society of Vertebrate Paleontology, 9th Annual Meeting. Nov. 10-12, 1949, Cortez Hotel, El Paso, Texas.

New Human Fossil Found In South African Cave

LONDON, Aug. 24 (Science Service — Another very early human type has been discovered in South Africa, source of many new human and near-human fossils in recent years. This newest find, which is more nearly human than some of the others, was made in the same cave that a short time ago yielded the jaws and skulls of a huge ape-man that was given the name *Paranthropus crassidens*.

The new fossil consists only of a lower jawbone, in which five molar teeth are still fixed, with the sockets of other teeth well preserved. It was found by J. T. Robinson, and is reported in *Nature* by him, together with Dr. Robert Broom. Both researchers are on the staff of the Transvaal Museum in Pretoria. They have given their new type the name, *Telanthropus capensis*.

The Telanthropus jaw is described as of ordinary human size — no larger or more massive than many modern jawbones. The two wisdom-teeth, however are larger than any known similar modern tooth. While it is primitive in many respects, it is quite definitely human. Nearest resemblance is to the lone, and still puzzling Heidelberg jaw, found in Germany many years ago. Like Heidelberg Man, Telanthropus was rather lacking in chin.

Site of the discovery, and poverty of the adjacent area in datable fossils of other animals, leaves the age of the new type in some doubt. The early Pleistocene seems likeliest.

Map Published of Paleocene Deposits of Rocky Mountains and Plains

WASHINGTON, Aug. 25 — The Geological Survey has published a map of the Rocky Mountains and Plains region that shows the outcrops of Paleocene or earliest Tertiary rocks.

This progress map is in part a compilation from published and unpublished sources, checked by field work, and original mapping by R. W. Brown. It is the culmanation of an intermittent study begun in 1929 concerning the boundary between the Cretaceous and Tertiary strata of the Rocky Mountains and Plains, about which there has been considerable divergence of opinion since 1860. Investigation of the strata and the plant and animal fossils involved in the problem now permits an accurate drawing not only of the lower but also of the upper boundary of the Paleocene series in most of the area. This contribution toward the solutuion of a dificult geologic problem and the resulting geo'ogic map may be of direct use in aiding in the search for new oil fields.

The map, titled "Paleocene deposits of the Rocky Mountains and Plains," by Roland W. Brown, is in one sheet, on a scale of 1:1,000,000, and includes a column of concise descriptive text. Copies may be purchased for 60¢ from the Director, U. S Geological Survey, Washington.

Cover Photo

This month's cover photo is of a mobile blaster's platform used for charging drill holes in the underground quarry at the Oil-Shale Demonstration Plant near Rifle, Colorado, where the Bureau of Mines is determining the costs and methods for mining oil shale on a commercial scale. Bureau of Mines photo.

THE BLISTER HYPOTHESIS AND GEOLOGICAL PROBLEMS

C. W. WOLFE
Boston University

Due to the extensive interest in the recently published accounts of the Blister Hypothesis in the Annals of the New York Academy of Sciences and in the Scientific American, the editor has asked Dr. Wolfe for a discussion of the same for the Earth Science Digest readers.

Many unsolved problems still confront the geologist; and where there are unsolved problems, hypotheses, far outnumbering the problems, are offered for their solution. Five of these problems are:

1. The origin of continents and ocean basins.

2. The origin or origins of crustal movements, resulting in domes, basins, compressional mountains, and fault block mountains.

3. The origin or origins of different types of igneous rocks, particularly gabbro basalt and granorhyolite types. Corollary: the association of many ore deposits with igneous rocks.

4. The association of volcanism with zones of mountain building.

5. The association of wide scale metamorphism in post Archean rocks with mountain belts.

There is no immediate apparent reason for believing that one operative process may be the answer to all these questions; but the prevailing association of crustal movements with each of the other four problems might lead one to suspect that the same causal force is the answer to all of the problems listed above. The recently proposed Blister Hypothesis of the author attempts to suggest the origin of this force and the expected sequence of events which would follow from its operation.

THE BLISTER

According to the hypothesis, radioactivity in the outer 400-450 miles of the earth generates heat faster than it can be removed by simple conduction through the crust. There is nothing novel in this suggestion, as others have given it before. Neither is the suggestion the outcome of the recent accentuated interest in radioactivity, for the hypothesis first took form some eight years ago. Now, if heat is generated faster than it can escape by simple conduction, various sectors of the crust must become gradually heated. It is unlikely that there is a completely homogeneous development of this heat accumulation, and thus we find certain regions with a greater heat content than others at different times. The presence of the heat energy is manifested by an increase in volume of those regions. Thus,

Blisters, which are expanded sub-crustal sectors, are born.

In the early stages the blisters will be relatively small (a matter of a few miles) and are then known as *Pocket Blisters.* It seems likely, although unnecessary, that above a certain depth in the crust, heat dissipation by conduction and radiation would equal the heat generated in that zone plus the heat conducted to the zone from the region below. This level is thus known as the *isothermic level.*

Below the isothermic level the rocks continue to warm; and since conductivity is diminished in rocks with increased temperature, and since radioactivity proceeds at a constant rate, there is a gradual acceleration in heating. Concomitantly, the heated zones become larger by extending laterally and in depth. Heating of rocks results in their volumetric expansion. The physical state of the rocks to expansion, that is, crystalline or glassy, is of little importance. Whatever the state, continual heating will eventually yield liquid rock or magma, and if pressure on the blister sector if reduced sufficiently, adequate super heat may be present to transform an expanded glassy phase into magma, although no magna actually exists in the body of the blister.

SURFACE EFFECTS OF THE BLISTER

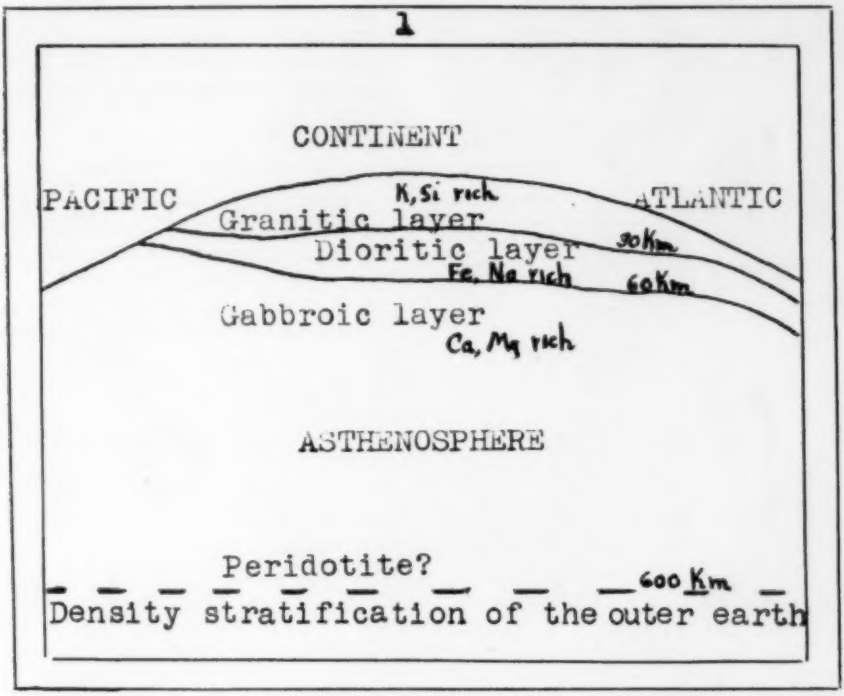
Whether or not there be an isothermic level, the greatest expansion in the blister area will be in depth, for heat loss would be least there. Necessarily, then, as the blister expands, the surface rocks are lifted into a broad dome. Two immediate results of this doming can be envisioned. Above the blister, particularly in the central portion, the brittle surface rocks would tend to fracture, and if the fractures reach down to the super-heated blister area, magma will rise along the fractures to form fissure lava flows and flowing volcanos. From the compositions of these magmas, it is possible to infer the depth of the isothermic level and, conversely, the character of the rock shells in the crust.

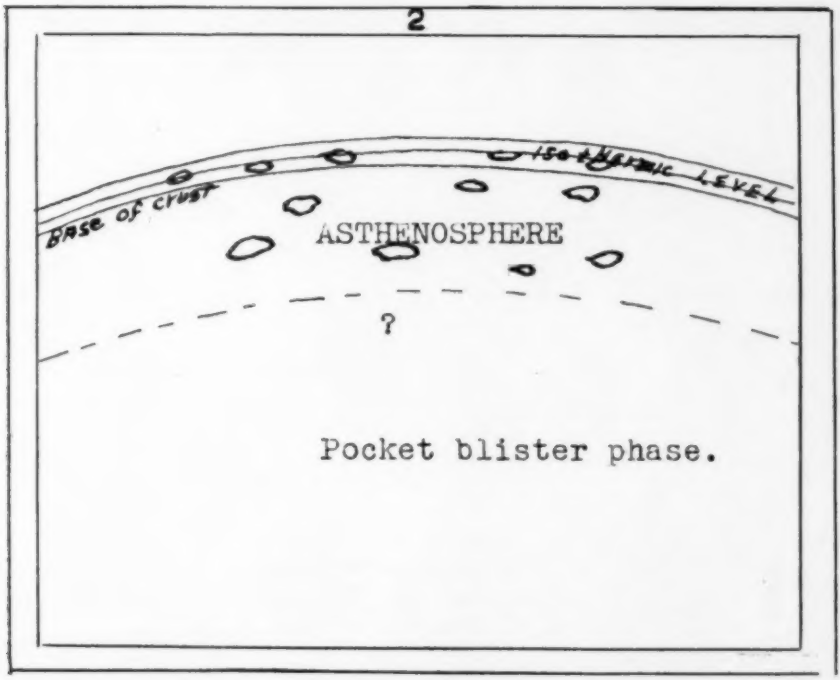
The second result of the doming above the blister is a stretching of the crust around the blister, for the entire supra-blister crust is lifted like a gigantic lid. Somewhere in a weak sector at the margins of this blister lid, the surface rocks fracture, and the weaker rocks below (which possess no super heat) yield by plastic flow. The net result is a thinning of the crust in the marginal area, and thinning means weakening. Thus, a long trough or *geosyncline* develops in the weakened area.

EVOLUTION OF THE GEOSYNCLINE

A small amount of depression takes place in the geosyncline due to the actual stretching by the blister expansion. Four other causes for continued and greater depression develop thereafter. The first of these is sedimentation. Geosynclines may develop on land or beneath the sea, and in the latter case, sedimentation is not a factor in the continued deepening of the trough. Where sediments collect in troughs along the shores or in troughs on land their weight tends to depress the bottom beneath them. The amount of depression, however, is never equal to the thickness of the sediments, for the sediments have a much lower density than the plastic sub-trough material which is displaced to either side by the downward pushing sediments. Thus, any initial trough would be rather quickly filled by a shallow blanket of sediments if other causes of depression were not present.

The third cause of continued depression in the geosyncline, once


1
CONTINENT
PACIFIC
K, Si rich
Granitic layer
ATLANTIC
30 Km
Dioritic layer
Fe. Na rich
60 Km
Gabbroic layer
Ca, Mg rich
ASTHENOSPHERE
Peridotite?
600 Km
Density stratification of the outer earth


2
BASE OF CRUST
ISOSTATIC LEVEL
ASTHENOSPHERE
?
Pocket blister phase.

it has begun, is the periodic collapse of the Blister roof as magma escapes from below. It will be readily seen that an arc of the crust which drops to a position closer to the center of the earth must necessarily make room for itself either by wrinkling of itself or of the area immediately adjacent. Since the adjacent area has already been weakened, it is more likely to yield to compression than the supra-blister crust; and thus, it is downfolded further to make room for more sediments which will deepen it even further.

The fourth cause of the geosynclinal depression is the lateral thrust of a supra-blister crust which has been greatly lengthened by intrusions which have solidified along fissures above the expanding blister. There are many known sections of good rock exposures where the area of dikes is at least 5% of the total area. This means of course that if such a condition existed over a blister 500 miles wide that the length of the crust perpendicular to the longest direction of the trough would be increased 25 miles; and since the over all radius of the blister roof does not increase in proportion, the crustal lengthening must be manifested by a folding, as suggested in the preceding paragraph, in the geosynclinal region.

A fifth cause for continued depression of the geosyncline is the periodic intrusion of magma from a depth sufficiently below the geosyncline to give the rising magma adequate super heat. Some of the magma solidifies within the sediments as sills, dikes, and laccoliths. Other magma is extruded, forming volcanos and extensive deposits. All of these igneous rocks, whether intrusive or extrusive are dark and dense and add to the weight of the sedimentary section of the geosyncline. This increased weight causes an additional sinking which is made very easy by the developing space made available by the removal of the magma from depth.

METAMORPHISM OF THE TROUGH SEDIMENTS

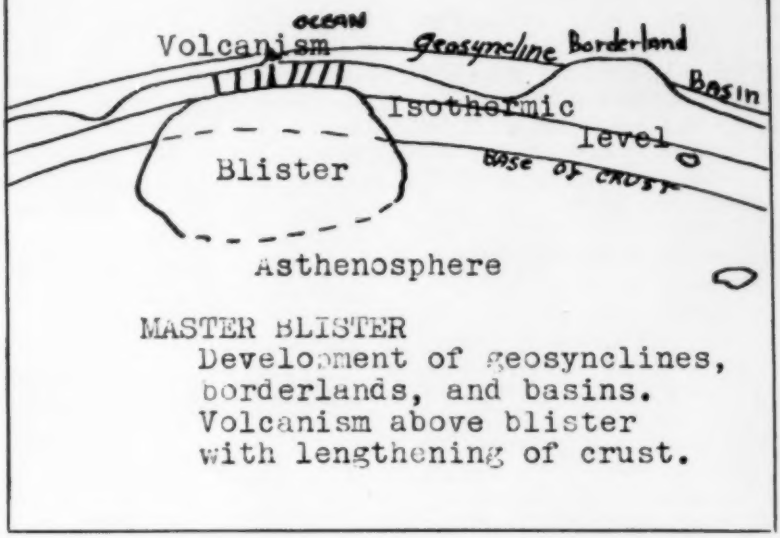
As the base of the geosynclinal sediments sinks lower and lower, the heated blister area is extending laterally toward the trough. After a time the temperature at the base of the poorly conducting sediments begins to rise pronouncedly because of the approach of the blister. The sediments contain perhaps as much as 25% by volume of water, either marine or fresh, depending upon where the trough was located when sediments were introduced. The sediments in the presence of this heated water begin either to dissolve or to recrystallize, forming the typical minerals and rocks of metamorphic belts. The recrystallization takes place in an environment of directed pressure, and consequently, the newly forming mica or other non-equant minerals become aligned with their flattest direction perpendicular to the direction of compression.

The degree of recrystallization and the extent of solution are dependent upon the amount of water present and its temperature. Since the latter is a function of the distance from the blister heat source, definite zones of metamorphism develop with different minerals characterizing each zone. Distance from the heat source and the presence of heated connate water, then, are the controlling factors in metamorphism, not dry heat or pressure — of either the static or directed types, according to the hypothesis.

DEVELOPMENT OF GRANITIC MAGMAS AND ORE SOLUTION

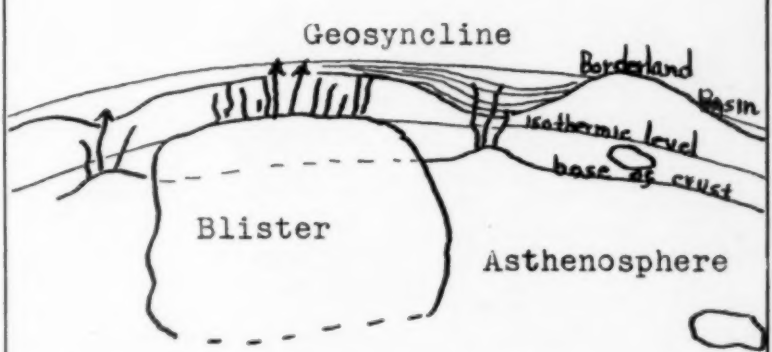
As the temperature at the base of the geosyncline continues to rise,

3



MASTER BLISTER
Development of geosynclines, borderlands, and basins. Volcanism above blister with lengthening of crust.

4



Geosyncline phase with volcanism into sediments. Continued volcanism above blister.

the sediments and perhaps much of the basement are dissolved to form magma. The nature of this magma must necessarily be rather granitic in character, for the average composition of the dissolved sediments is that of the surface rocks of the earth which tend toward that composition. Actually, the magma will vary considerably in composition from region to region; and as the magma stands, it may differentiate in place still further. Thus, many unusual types of igneous rocks form, rocks which, in a very real sense, are hybrids. Recently formed granitic rocks, therefore, are the result of *palingenesis* (formation of a new magma from old rocks) of earlier crystallized rocks of the same composition. In the final analysis, it is suggested that the original crust was granitic, and granites formed thereafter are largely the result of reworking of that primeval crust.

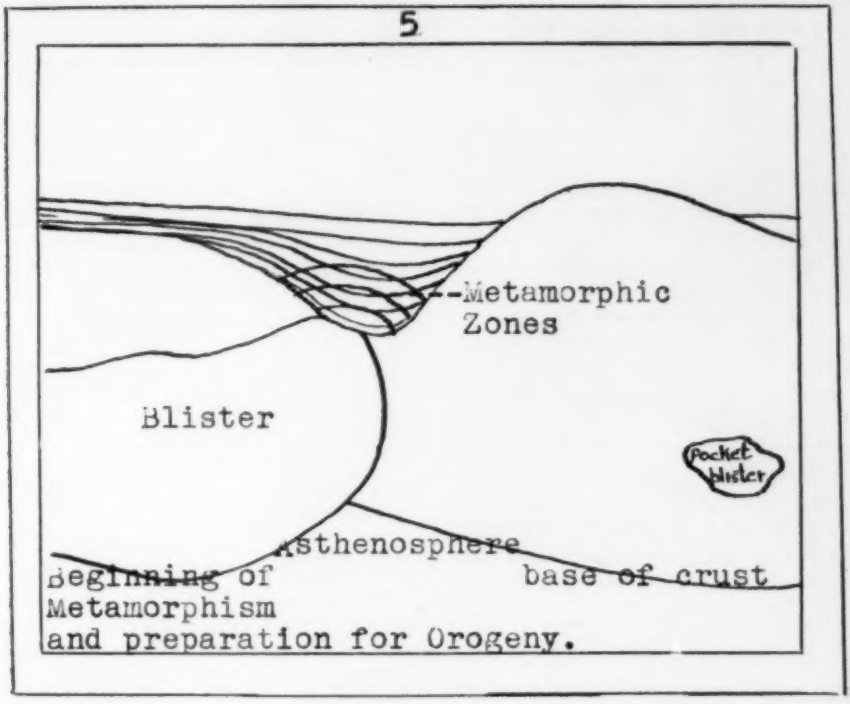
All sediments and also sea water trapped in the sediments contain various quantities of rare elements. When magma is formed from these sediments and from the water, processes of concentration gradually bring these widely disseminated metals into sufficient concentration to make economic mineral deposits when the solutions which bear the metals ultimately invade rocks surrounding the intruding magma. Of course, this origin of ore deposits is limited to those metals which are found in association with granite or hybrid rocks. Many ore deposits have obviously different origins.

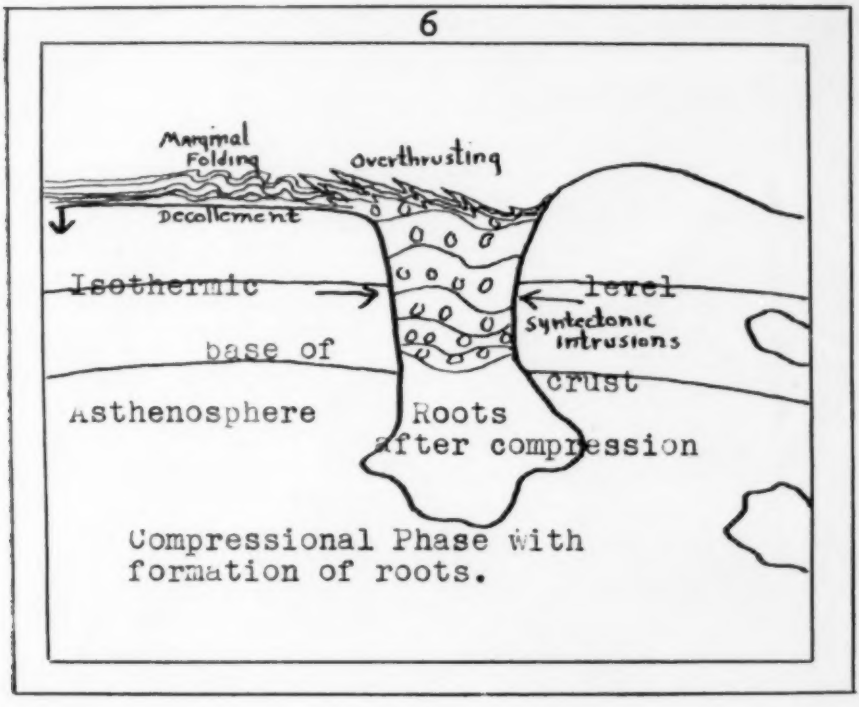
COLLAPSE OF THE BLISTER AND FOLDING OF SEDIMENTS

As the lower part of the geosyncline is weakened extensively by heat from the approaching blister, the raised roof of the blister tends to push downward. Gravitational force is probably the greatest available force for mountain building that has yet been proposed, and has been variously used in other hypotheses. In earlier paragraphs it was demonstrated that the collapsing roof would produce considerable lateral compression because of the smaller arc and the lengthening of the crust above the blister by solidification of fissure magma. If sufficient heat is lost through vulcanism, the shrinkage of the roof may be far greater than its former expansion.

When the blister has extended laterally far enough to excessively weaken the geosyncline, the dropping of the blister roof is accompanied by wholesale folding of the lower part of the geosyncline, while large overthrust masses form near the surface. The folding and the overthrusting do not produce great mountain heights. Rather, the yielding to the compression is largely downward into the plastic substratum beneath the geosyncline. Thus, great mountain roots, possibly affecting the entire region to a depth of 450 miles below the trough, are formed. (This may be an explanation for deep focus earthquakes.) The various zones of metamorphism which were previously induced may be folded. Sediments at the margin of the geosyncline are folded or wrinkled as the basement on which they rest moves laterally toward the weak geosyncline, and the Appalachian and Jura types of folds are born.

Coupled with the folding vast quantities of the palingenetic magma are forced into and between sedimentary strata and the typical conformity of intrusions of this period is produced. It is understood, of course, that the magma is forcefuly injected, not through any force within itself, but through the force of the collapsing blister roof.


5
Metamorphic Zones
Blister
Pocket blister
Asthenosphere
Beginning of Metamorphism and preparation for Orogeny.
base of crust


6
Marginal Folding
Overthrusting
Decollement
Isothermic level
syntectonic intrusions
base of crust
Asthenosphere
Roots after compression
Compressional Phase with formation of roots.

UPLIFT OF THE MOUNTAINS AND LATE IGNEOUS ACTIVITY

It is a well known geological principle that various sectors of the earth's crust obtain a state of floating equilibrium (isostasy), if sufficient time elapses. The low density mountain roots must, therefore, tend to float gradually upward along steeply digging fractures (reverse faults), and typical late orogenic fault block mountains develop. Prior to this uplift considerable quantities of magma, mostly hybrid, will migrate toward the surface from the roof region (*piece meal stoping*). During and after the uplift more dense magma (usually andesite or basalt) will rise along the fractures forming extension flows or sills in the basins which develop between mountain ridges.

Eventually uplift will be complete; erosion will wear down the newly formed mountains; and further blister activity will start the cycle once more by the formation of a new geosyncline.

SUMMARY AND ILLUSTRATIONS

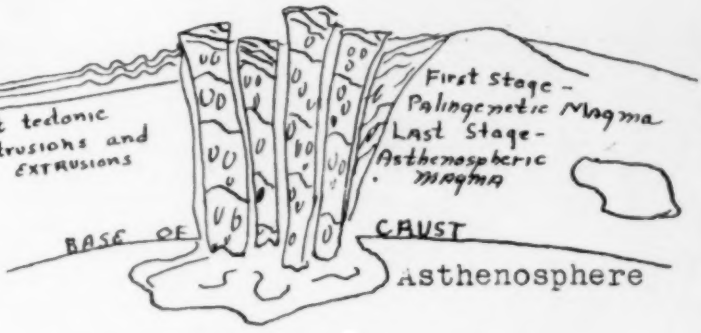
The Blister Hypothesis then serves to explain the problems mentioned at the beginning of this paper. Continents are roofs of blisters or aggregates or thickened lown density root sectors. Ocean basins, except the Pacific, are collapsed blister roofs. (The author believes the Pacific basin to be the result of the ejection of the moon from the earth at the beginning of Archean time.) Crustal movements result as adjustments to expanding or contracting blisters. Magmas for the various igneous rocks result from the accumulation of heat in blister areas, and many recent ore deposits are concentrations of rare minerals from sediments and trapped sea water during the palingenesis of the lower part of the geosyncline. Metamorphism in the mountain belts is explained as the result of the dual activity of heat from the blister and water trapped in the sediments.

The hypothesis also gives a ready explanation for the well known ebbs and flows of seas across the lands in past geologic time, and explains readily the appearance and disappearance of borderlands, troughs, and basins.

To the author there is little doubt that blisters exist today, and a careful study of the earthquake activity, vulcanism, and altitudes of different areas can serve to approximate their location. Much of Africa, a large part of western United States, Mongolia, and other sectors, may represent modern blister areas. The East Indian region probably represents a collapsed blister roof with many of the border islands rising above deeply set roots. It is impossible in this short article to give the evidences for these statements. All that can be said here is that where the author has applied the Blister Hypothesis to the facts of geology, they have become understandable, and neatly fit into a comprehensible, integrated picture of the history of the earth.

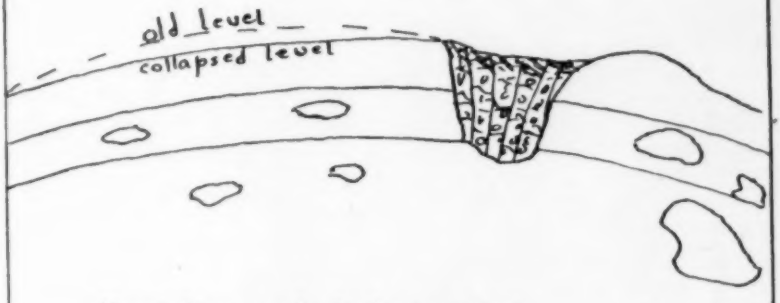
The figures have been prepared by Miss Virginia Franklin.

7



Isostatic Uplift and Fault Block Phase

8



Erosion and Quiescence with formation of new pocket blisters.

Bad Quakes Are Frequent In The Andes

WASHINGTON, Aug 10 (Science Service) — Disastrous earthquakes are no new thing to Ecuador and the Andean region generally. Seismologists of the U. S. Coast and Geodetic Survey here, combing over their files, found records of one in Guyas province on May 14, 1942, that killed 200 people and ruined $2,500,000 worth of property. Farther back, on Jan. 31, 1906, there was an undersea shock off the Ecuadorean coast, about 100 miles northwest of last week's epicenter. The earthquake did no direct damage on land, but a sea wave which it started killed 600 people. That was one of the severest quakes on record, with a magnitude of 8.5.

That year, 1906, was a big one for earthquakes generally. April 18 was the date of the beginning of the San Francisco disaster; the quake that started the fire was of magnitude 7.5. On Aug. 16 of that year, Valparaiso, Chile, was hit by a very severe earthquake (magnitude 8.25), which killed 3,700 people and caused a quarter-billion-dollar property loss. On the same day there was an eighth-magnitude shock in the lonely Aleutian islands. Fortunately that one found no people to kill and no property to destroy.

The heaviest earthquake-caused loss of life of record in South America occurred at Chilien, Chile, on Jan. 24, 1939. The death-list for that shock climbed to 25,000.

The most recent Andean quake disaster, until last week, was the earthquake at San Juan, Argentina, on Jan. 15, 1944. Of magnitude 7.5, it caused $100,000,000 property damage. Loss of life was reported merely as "heavy."

Iodine From Oil Wells Supplies Nearly Half The American Need

NEW YORK, Aug. 17 (Science Service) — Nearly half the 1,500,000 pounds of iodine used annually in America now comes from oil wells, according to an article in the current issue of *Industrial and Engineering Chemistry*. The iodine is obtained from a brine that comes up with the oil.

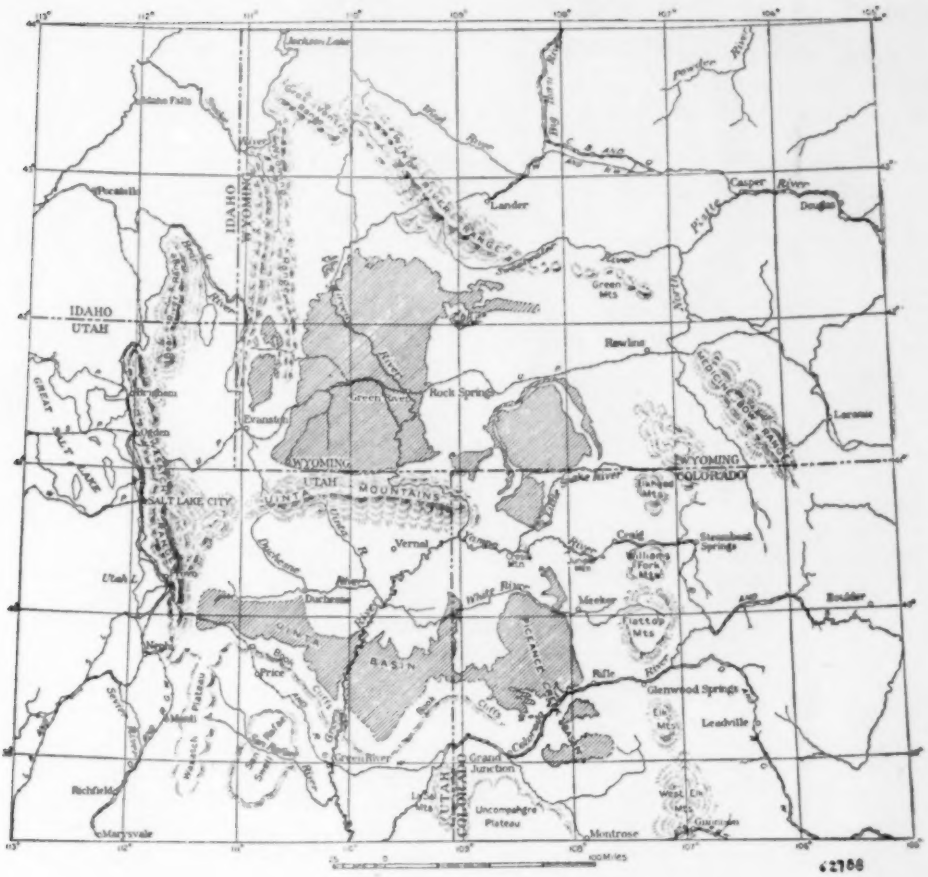
Obtaining iodine from oil-well brine is not new. Its first recovery from this source was in 1926 in Louisiana. Oil wells on the West Coast, however, are now supplying the widely used chemical in large amounts, decreasing greatly the amount that must be imported.

Much of the iodine used in the United States comes from Chile, where it is found as an impurity in saltpeter. Some comes from Japan where it is obtained from the ashes of seaweed. There is considerable iodine in ordinary seawater, but not enough to make its recovery economical.

In the process of recovering iodine from oil-well brine, the chemical is literally blown out of the oil brines in huge towers built with acid-proof bricks, this article states. It is then captured from the air and solidified. The report, prepared by Frederick G. Sawyer, of the *Industrial and Engineering Chemistry* staff, in collaboration with M. F. Ohman and Fred E. Lusk of the Dow Chemical Company, asserts that sufficient quantities of oil-field brine are available in this country so that in an emergency the entire iodine requirement could be obtained from domestic sources.

THE GREEN RIVER OIL SHALES

JEROME M. EISENBERG



The Green River oil shale formation of Colorado, Utah, and Wyoming, indicated by the shaded areas on this U. S. Geological Survey map, is estimated to contain more than 300 billion barrels of oil. The Oil-Shale Demonstration Plant of the Bureau of Mines is just west of Rifle, Colorado (lower right), and the Petroleum and Oil-Shale Experiment Station at Laramie, Wyoming (extreme right).

The Green River oil shale formation of Colorado, Utah, and Wyoming is one of the world's largest single economic mineral deposits, covering an area of 16,460 square miles, and is considered to have the highest prospective value of any known oil shale deposit.

The oil shale of the Green River formation is not actually a true shale, nor does it contain oil as such. It is magnesium marlstone

containing kerogen, the carbonaceous remains of primitive aquatic animals and plants. When this organic matter is vaporized by heat, it forms a condensate of shale oil. The marlstone is a tough fine grained rock with a laminar structure. It varies in color from a brown or reddish brown, grey or bluish grey, to black. It does not appear oily, however pieces rich in kerogen can be ignited with a match.

Geology

Northwestern Colorado and east-central Utah were covered by a broad shallow lake (Uinta Lake) during the middle Eocene epoch, about 45 million years ago. Southwestern Wyoming was covered by a second lake (Gosiute Lake). The Green River formation was deposited at this time as sediments on the lake bottoms.

The oil-shale zones are richer in the center of the lake basins, for it was there that the organic matter was most abundant, dimishing toward the margins of the lakes. W. H. Bradley estimates that these sediments were laid down at the rate of one foot every two thousand years, thus giving the Green River epoch a period of formation of from five million to eight million years.

Some three thousand feet in thickness, it is divided into the following members: Evacuation Creek, with a thickness of one thousand feet; Parachute Creek, seven hundred to thirteen hundred feet thick; Garden Gulch, 630 to 720 feet thick; and Douglas Creek, 430 to 470 feet thick. The principal beds of oil shale occur in the Parachute Creek member. In this area the oil shale is divided into three zones, from 200 to 630 feet thick. They are separated by 50 to 150 foot zones of marlstone, nearly free of oil. In some places the oil shale zones are continuous, forming a bed 1300 feet thick.

The Green River formation is overlain in places by the middle and upper Eocene Bridger formation or by lava, and it overlies conformably the lower Eocene Wasatch formation.

Occurrence

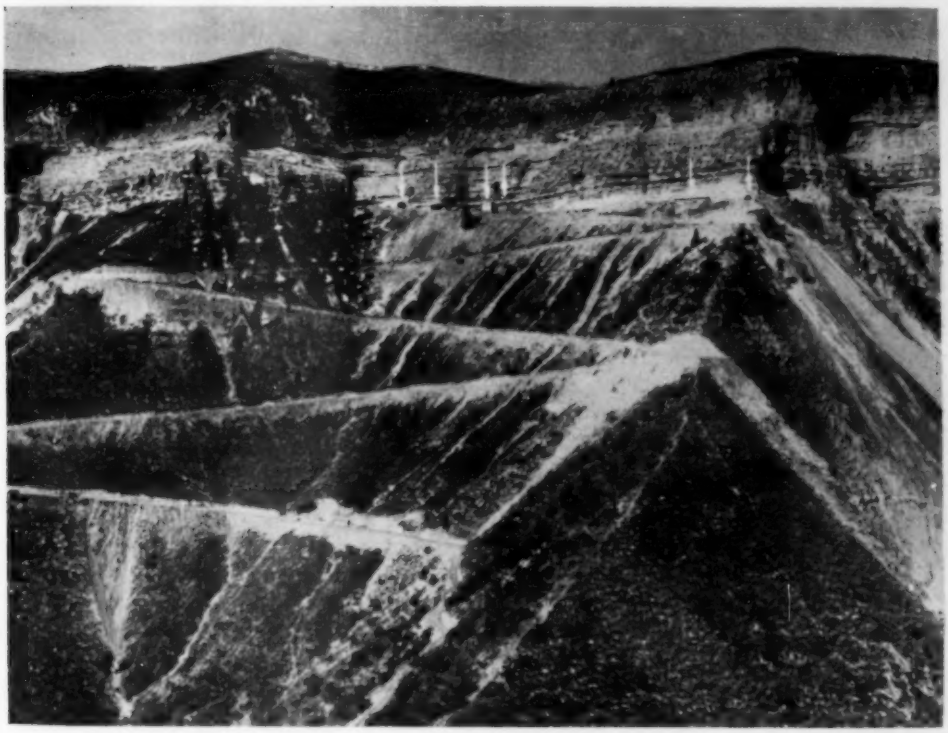
COLORADO. The Green River formation covers 2590 square miles of Colorado. 700 miles of this is covered by the Bridger formation and igneous flows.

The oil shale of the Piceance Creek Basin, in western Colorado, covering 1655 square miles, is apparently the richest and thickest of the known beds. The principal measure is about 500 feet thick and yields about 15 gallon of oil shale a ton. This is considered a medium grade oil shale. A rich section of this measure, known as the Mahogany Ledge, is now being mined. Ranging from 70 to 100 feet thick, it yields an average of 30 gallons of oil per ton.

The oil shale reserves in this area are estimated at 300 million barrels of shale oil per square mile. With an area of about 1000 square miles, it contain 850 million tons of shale, which could yield a total of 300 billion barrels of shale oil.

UTAH and WYOMING. 4680 square miles of east-central Utah are covered by the Green River formation. 1600 square miles of this is covered by the Bridger formation. The oil shales of Utah contain about 43 billion barrels of shale oil.

South-west Wyoming has 9190 square miles of the Green River formation, 4200 square miles of which is covered by the Bridger formation. The oil shales of



Bureau of Mines photo

As indicated by arrows, these Bureau of Mines experimental oil shale mining facilities near Rifle, Colorado, are, from left to right, the two portals of the underground quarry, the office and warehouse building, change house, shop and compressor building, and the haulage portal of the Selective Mine.

Wyoming contain about 3 billion barrels of shale oil.

Mining

An experimental oil shale demonstration plant has been constructed at Rifle, Colorado, by the U. S. Bureau of Mines. This plant has been mining and retorting the oil shale for about two years. A refinery has just been constructed, and soon finished products will be produced from the shale oil.

At this area the main measure of oil shale outcrops in massive horizontal beds in almost vertical cliffs at an elevation of from 8000 to 8500 feet. A large underground quarry has been developed in the Mahogany Ledge. The Mahogany Ledge is at the bottom of an escarpment 600 to 800 feet in height and is about 3000 feet from the valley floor. It is mined in three benches, with a 60-foot roof span and 60-foot square pillars. About 1500 tons of shale are being mined a day, a total of 40 tons per man. The shale is heated or retorted, and the kerogen is cracked to yield oil and gas. It is then refined, yielding acceptable industrial fuel oil.

Bureau of Mines photo

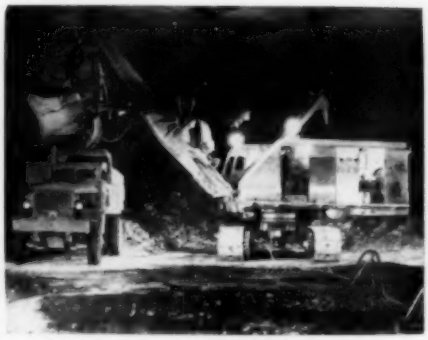
Miners are shown removing loose oil shale from the face and roof of the underground quarry at the Bureau of Mines Oil-Shale Demonstration Plant near Rifle, Colorado, with the aid of a portable scaling rig.

At the Petroleum and Oil-Shale Experiment Station at Laramie, Wyoming, an extensive program of research is being carried out, including mineralogical studies of oil shale; studies of the regulations of time, heat, and temperature, for the conversion of kerogen to shale oil; and research on the different methods of recovering oil from shale.

REFERENCES:

CARL BELSER, "Oil Shale Resources of Colorado, Utah and Wyoming," American Institute of Mining and Metallurgical Engineers Technical Publication No. 2358 (May 1948).

JAMES BOYD, "Progress in Oil Shale Development and Research," The Mines Magazine, December 1948, pp. 47-50,64.



Bureau of Mines photo

In a single bite, this electric shovel loads three cubic yards of broken oil shale into a 15-ton Diesel truck deep within the underground quarry at the Oil-Shale Demonstration Plant of the Bureau of Mines near Rifle, Colorado.

Water Resources In August

Ground-water levels and stream flow in the West generally receded by more-than-seasonal amounts. The flow of the Colorado and Columbia Rivers was subnormal. The drought in the Northeast continued unabated in August. Ground-water levels and stream flows were reported lowest of record for August at several locations.

An earthquake on August 21 whose epicenter was off the coast of British Columbia was recorded in fluctuations in ground-water level in the lower peninsula of Michigan ranging from 0.01 foot to more than one foot.

Excessive stream flow occurred in the Southeastern States, in part as a result of a tropical hurricane that crossed the coastal States on August 26-28. No major floods were reported.

— *Water Resources Review*

FOSSILS IN THE OLD RED DRIFT OF PIERCE COUNTY, WISCONSIN*

THEODORE C. VANASSE

Fossil invertebrates in the Illinoian drift of Pierce County are usually preserved in chert. Exceptions are the calcite and aragonite coquinas from the near-by Platteville and Decorah formations, and the rare jasper pseudomorphs of corals and brachiopods. Still rarer are the limonite and opal replacements — the limonite being possibly an alteration from the pyrite and marcasite fossils found in one or two local exposures of the Glenwood Shale.

The oldest fossil recognized in the drift is the agatized or jasperized algae, of Huronian age. Much of this material is beautifully colored, well preserved, and suitable for lapidary work.

Cherty masses of Stromatopora, the problematical sponge, Pasceolus (Cerionites) dactyloides, and a variety of Bryozoans are relatively common in local areas. Corals, however, in varying states of preservation and of various forms of fragmentation are most common. During a period of perhaps ten years the following corals were gathered in the fields of my farm;

Favosites gothlandious
Favosites venustum
Zaphrentis
Streptelasma
Strombodes
Heliolites
Columnaria alveolata
Columnaria sp.
Syringopora
Cyathophylloid corals
Numerous unidentifed fragments.

Brachiopods are often found, and although mostly unidentified, Pentamerus, Rafinesquina, Spirifer, Herbertella, Rhynchotrema, Orthis, and Lingula are known. Gasconadia, from the Oneota, is common; Orthoceras and Oneotoceras less common; and occasionally one finds iron-stained masses of pelecypod coquina from the Maquoketa. Identified trilobite fragments include Encrinurus and Platycolpus, and perhaps it is not surprising that none of the numerous Cambrian genera is found since no soft rocks remain in the ancient drift. Other specimens include an adundance of crinoid columnals and a single complete calyx with arms, a single minute star fish, perhaps a dozen ostrocods, and a scattering of unidentified and strange fossil fragments.

Identification of most of the fossils is particularly difficult, both because of the nature of their preservation and because of their separation from the formations in which they were deposited. While many specimens can quite definitely be attributed to their proper horizons, many others cannot. Cherts in the iron-bearing drift alter so that specimens from the Niagara, for example, are indistinguishable from specimens from the Oneota. Other specimens alter to cause confusion in many ways; for example, Platteville brachiopods occur in bits of highly jasperized

*Reprinted in part from **The Trilobite,** official publication of the Wisconsin Geological Society.

chert — a condition unknown, at least locally, in the Platteville.

Occasionally however, corals and brachiopods are found in an excellent state of preservation that surpasses the conditions usually found in the native or parent strata. Favosite corals may show every mural pore as a tiny cylindrical projection of hard chert. Internal casts of Leptaena may show in minutest detail all features of muscle attachment and hinge line structure.

ENORMOUS COAL RESERVES OF MONTANA APPRAISED

WASHINGTON, Aug. 31 — Coal reserves in Montana of 221,779,000,000 tons in place recently appraised by the U. S. Geological Survey constitute an assured and abundant source of fuel that will be available when needed to supply synthetic fuel plants. More than 28,000,000,000 tons of lignite and sub-bituminous coal or about 12 percent of the total reserve is known to be present in beds 10 feet or more thick, lying under less than 2,000 feet of overburden, and less than 2 miles horizontally from the outcrop.

The new appraisal is the first of a series of state summary studies being undertaken by the Geological Survey as part of a program to reappraise the coal reserves of the United States. During the period since 1928, when the last coal reserve estimate for the United States was prepared, much new work has been done by the Geological Survey and State agencies on the thickness and distribution of coal. Similarly, new estimates have been prepared for several eastern states, and for many individual mining districts. But for most States, including Montana, and for the United States as a whole, no comprehensive re-appraisal has been undertaken.

The new appraisal of Montana coal reserves was prepared in greater detail than the earlier estimates by the Geological Survey, and presents the data by counties, by rank of coal, by classes of coal according to the reliability of the information on which the calculations were based, and by coal beds in several thickness groups. The total reserve of 221,779,000,000 tons is somewhat smaller than the earlier estimate of the Geological Survey, but the present estimate was made on a much more conservative basis, and is believed to represent a minimum figure. As new information is obtained it is expected that the estimate will be substantially increased.

In addition to several tables showing reserves in different categories in Montana, the new report contains two index maps showing distribution of coal fields, a brief text describing the geology and distribution of coal in the fields, and a comprehensive bibliography of the source of all the data used in preparing the estimate.

The report, titled "Coal Resources of Montana," by John X. Combo, Donald M. Brown, Helen F. Pulver, and Dorothy A. Taylor has been published as Circular 53 of the Geological Survey, and may be obtained without cost upon application to the Director, U. S. Geological Survey, Washington 25, D. C.

Earth Science Abstracts In Uranium Resources and Radioactivity*

ACTIVITY OF RADIOACTIVE INCLUSIONS IN IGNEOUS ROCKS Renè Coppens. Compt. rend. 228, 176-8 (1949) Jan. 10 (In French).

It has been shown by Hèe (Compt. rend. 227, 356 (1948) that the radioactivity of igneous rocks is traceable to radioactive inclusions. The present author used the photoemulsion method for the determination of the U and Th content of rocks, by counting alpha-tracks produced by such inclusions, per cm^2 and per sec. Rock powder was placed upon Ilford C2 emulsions, the exposition time varying between 7 and 18 days. In most cases, prolonged trajectories meet upon a well delineated small surface corresponding to the inclusions. The formula used is that given by I. Curie (J. phys., (1946) Nov) which, after substitution of constants, has the form $N = 8.4KC(U) + 2.5KC(Th)$; here N is the number of trajectories, C (U) and C(Th) are the concentrations of U and Th, and K is a coefficient varying between 14 for granite and 31 for uranium oxide and thorite. Using a second equation $C(Th) = 2.5C(U)$, the concentrations C(Th) and C(U) can be determined. The method was tested on seven samples of granitic sand and mica schist from Brittany. Their average contents was found to be about 10% U and 22% Th, with approximations of about 20%.

DEVELOPMENT OF URANIUM DEPOSITS AT MOUNT PAINTER, S. A. [South Australia]. **Chem. Eng. Mining Rev. 41**, No. 3, 85-8(1948) Dec. 10.

Uranium deposits were discovered near Mount Painter in 1910 and the area was worked intermittently for radium until 1934. Exploratory work was resumed in 1944, and has been carried on more intensively since 1946. The area being examined (about 150 sq. miles) is 300 miles north of Adelaide and 60 miles east of Copley. The uranium-bearing deposits of Mount Painter are similar to those in Portugal and Bulgaria where primary uranum minerals are disseminated through granite and pegmatite and have given rise to secondary enrichments.

FORMATION OF RADIOACTIVE SURFACE FILMS ON MINERALS. T. G. Church. National Research Council of Canada Report CRC-407, nd, 8 p.

This report describes experiments performed to determine whether mineral surfaces could be made radioactive by undergoing exchange reactions with radioactive ions in solution. Such radioactive coatings, if selective, would serve as a means of differentiating between minerals in an ore and enable them to be separated mechanically by a Geiger counter operated device, such as the Lapointe ore-sorter. It was found that specific minerals in an ore can assume a surface radioactivity by undergoing reactions with radioactive ions in solution. It is essential that the mineral have a suitably tarnished or coated surface, for, in general, no exchange will occur on a fresh surface. It is suggested that the radioactivity so induced could be used in conjunction with a mechanical device to separate and concentrate valuable minerals or to control plant processes.

*These abstracts, appearing in NUCLEAR SCIENCE ABSTRACTS, Vol. 3, Nos. 1-4 (July 15-August 30, 1949), are reprinted by permission of the United States Atomic Energy Commission, Technical Information Branch, Oak Ridge, Tenn.

MEASUREMENT OF RADIOACTIVITY AND TEMPERATURE IN NARROW BOREHOLES, AND THE DEVELOPMENT OF INSTRUMENTS FOR THIS PURPOSE. R. Guelke, J. C. R. Heydenrych, and F. Anderson. **J. Sci. Instruments 26,** 150-3(1949) May.

The development of instruments for measuring the temperature and radioactivity in boreholes, to determine the position of the various geological formations under special conditions encountered in South Africa, is described. Special mention is made of size considerations and of the necessity for making the instruments self-contained so as to enable a single insulated wire to be used for hoisting purposes.

PORTABLE COUNTER FOR GEOLOGICAL RESEARCH. O. J. Russell. **Electronic Eng. 21,** 173-4(1949) May.

A portable counter which has been developed for prospecting for radioactive uranium and thorium minerals, for general geological investigations, and as an ultra-sensitive detector of lost or mislaid radium, is described. The aforementioned general usage includes the identification of changes in strata by means of the investigation of the slight amount of residual activity present in most minerals. The apparatus, which consists essentially of a scaled-down version of a standard laboratory Geiger-Muller counter, is highly sensitive since a variation equivalent to 4% of the cosmic ray background can be detected by a three-minute count.

PROSPECTING FOR URANIUM ORE USING G-M COUNTERS. Samuel Freedman. **Radio Electronics 20** No. 10, 36-8(1949) July.

A few of the Geiger-Mueller counters which are useful in prospecting for uranium ore, because of their simple construction, low cost, and satisfactory operating characteristics, are described. Circuit diagrams of four such counters are shown.

THE RADIOACTIVITY OF SEDIMENTS. E. N. Tiratsoo. **Petroleum 12,** 177-22 (1949) May.

Potassium is an element of considerable geological importance, since its radioactive isotope is a source of significant energy. This paper describes a method of rapidly determining the potassium content of evaporites and rock samples which has obvious potentialities in oilfield correlations. The technique may have especial application in salt dome areas or where drilling is being undertaken for valuable potash salts. The author concludes from the experimental data examined that the radioactivity of sedimentary rocks is largely related to their content of potassium.

THE RADIOACTIVITY OF THE EARTH. C. Festa and M. Santangelo. **Ann. Geofisica I,** 581-609(1948) Oct. (in Italian).

The various problems connected with geological radioactivity determinations are discussed, and the methods and instruments in use are reviewed in detail. Tabulated data on naturally radioactive materials are included.

THORIUM IN SEA WATER AND MARINE SEDIMENTS. F. F. Koczy. **Geol. Foren. i Stockholm Forh. 71,** 238-42(1949) Mar.-Apr.

Experiments are described which show the precipitation of thorium in sea water. The adsorption of isotopes of radium and thorium on red clay, powdered manganous dioxide, and a powdered manganese nodule was determined. Radium adsorbed on all three powders, which is not the case with thorium. The thorium content of a few samples of marine sediments has been measured. They contain 1×10^{-7} g Th/g. One manganese nodule investigated was found to hold as much as 1.3×10^{-6}g Th/g. The geochemistry of thorium and uranium in sea water is briefly discussed. An attempt is made to estimate the

thorium content of sea water with the aid of the ratio Io: Th in the sediments. The thorium content of sea water is calculated to be 1 to 10×10^{-9} g Th/1.

☙

URANIUM RESOURCES. **Nucleonics 4.** 23-8(1949) May.

The occurrence of uranium in igneous rocks, hydrothermal vein deposits, sedimentary rocks, and other deposits of doubtful and complex origin is discussed as related to the percentages of uranium minerals usually found. The economic value of uranium is considered in terms of our estimated resources of that metal, and the program which has been adopted by the government to stimulate uranium discovery and production is summarized.

New Plastic Relief Map of Venezuela Produced

A big, colorful relief map of Venezuela — in lightweight plastic — is the unique, new public relations aid produced by Aero Service Corporation of Philadelphia for the Creole Petroleum Corporation. One thousand of the maps will be distributed in Venezuela by the oil company as part of its broad public relations program. The maps will be presented to Venezuelan schools, colleges, government offices, libraries, banks and similar institutions.

Though its size is 45x56 inches, this plastic relief map weighs only two pounds. Previously relief maps were made of heavy plaster — hand-formed, hand-lettered and hand-colored. They were both expensive and fragile. The lightweight plastic relief maps can be airshipped, but a thousand plaster models of this size would tip the scales at over 100 tons.

Unlike conventional, flat maps — which use darker colors at the highest points — the Venezuela maps emphasize the relief features with lightest color at highest elevations. The mountain peaks, for example, are a light lavender tone, shading on down thrugh successively deeper tones of peach and green to somewhat darker greens for the lower areas and valleys. The overall background of the map is a very pale peach; the ocean is light blue, with shorelines and inland streams a darker blue. Roads are printed in red; the contour lines, grid lines, and place names are black.

This map is based on a compilation of the American Geographical Society. Thirteen map sections were re-compiled, edited and re-styled for relief presentation by Aero Service Corporation. The map's scale is 1:1,250,000; its vertical exaggeration is 5 to 1. It covers an area of approximately 800,000 square miles. Copies of the map may be purchased from the manufacturer.

This company has made several thousand 17x22 inch plastic relief maps, representing typical geologic formations, for some 400 colleges' geology and geography classes. The Venezuela map is the first public relations use of plastic relief maps.

New Books

All books listed here are deposited in the Library of The Earth Science Institute and may be borrowed by the members. Books marked with an asterisk may be purchased through The Earth Science Publishing Co., Revere, Mass.

*GEOLOGY, PRINCIPLES AND PROCESSES,

by William H. Emmons, George A. Thiel, Clinton R. Stauffer, and Ira S. Allison. 3rd Edition. 1949. 502 pp., 488 figs.; $4.50. (McGraw Hill Book Co., Inc., New York). This new edition places a great deal of emphasis on the aerial interpretation of landscapes and geologic structures, illustrated by a number of aerial photographs. Two new units have been added to the text, one on the nature of matter and atomic structure, the other on soil and rock creeps, landslides, and related phenomena. A large amount of the factual data on atmospheric circulation, metamorphism, and vulcanism, present in the former editions, has been deleted.

*REVISION OF THE FAMILIES AND GENERA OF THE DEVONIAN TETRACORALS,

by Edwin C. Stumm. 1949. 92 pp. 25 pls.; $2.00. (Memoir 40, The Geological Society of America, New York.) The author has divided the Devonian tetracorals into 16 families, 18 subfamilies, and 127 genera. 3 new families, 5 new subfamilies, and 9 new genera are described. The genotype species of each genus are illustrated by the original figures.

OIL AND GAS IN EASTERN KANSAS, with Special Reference to Developments from 1944 to 1948,

by John Mark Jewett. 1949. 308 pp., 4 pls., 53 figs.; $0.25. (Bulletin 77, State Geological Survey of Kansas, Lawrence, Kansas). In part a revision of "Oil and Gas in Eastern Kansas" (Bulletin 57, 1945), this report treats separately each of the 43 counties lying wholly east of the 6th Principal Meridian. The surface and subsurface geology, oil and gas developments, and annual oil production in the various counties and fields are included in this report.

PITCHBLENDE OCCURRENCES BETWEEN BEAVERLODGE AND HOTTAH LAKES — NORTHWEST TERRITORIES,

by J. F. Henderson. 1949. 17 pp., 2 maps; $0.10. ** (Paper 49-16, Geological Survey of Canada, Ottawa). 38 pitchblende occurrences are mapped and described in this paper. The field work was done during 1945. Included is the general geology, economic geology, and methods of mapping and prospecting.

SOME CRETACEOUS SECTIONS ALONG ATHABASKA RIVER FROM THE MOUTH OF CALLING RIVER TO BELOW GRAND RAPIDS, ALBERTA,

by R. T. D. Wickenden. 1949. 32 pp. 1 fig.; $0.10** (Paper 49-15, Geological Survey of Canada, Ottawa). Bedrock sections exposed along the Athabaska River between Calling River and a point about 5 miles below Grand Rapids are described. Six formations are described, and fossils found are listed, with emphasis on the foraminifera.

A LA PECHE MAP-AREA, ALBERTA,

by E. J. W. Irish. 1949. 25 pp., 1 map; $0.10** (Paper 49-7, Geological Survey of Canada, Ottawa). Triassic to upper Cretaceous marine and non-marine sedimentary strata underlie the area. Physical features, general geology, structural geology and economic geology are included in the report.

**Remittance should be made by postal note or money order drawn payable to the Receiver General of Canada. (Geological Survey of Canada, Dept. of Mines and Resources, Ottawa, Canada.)

MINES OF ONTARIO IN 1947, by the Staff of the Mines Inspection Branch, Dept. of Mines. 1949. 143 pp.; free. (Annual Report, Vol. LVII, Part II, 1948, Ontario Dept. of Mines, Toronto). This report includes a detailed account of mining operations and statistical data on copper, fluorspar, gold, graphite, gypsum, iron, lignite, magnesium, mica, nepheline syenite, nickel and copper, silica, silver and cobalt, and talc.

Mexico's New "Volcano" Has Several Possibilities

WASHINGTON, Sept. 1 (Science Service) — The shepherd who was treated in Mexico for burns said to have come from a new volcano rising out of the earth southeast of Mexico City may have been the discover of volcanic Mexico's newest erupting mountain. But there are several other possibilities.

One is that he was too familiar with the story of Dionisio Pulido, a Mexican farmer whose corn field sprouted the now-famed Paricutin volcano only six years ago.

Only about two years ago, reports came of another "Paricutin," this one in Vera Cruz. The "volcano" was a fumarole, a hole from which gases or fumes issue. And the reports, which momentarily excited earth scientists, were merely designed to get publicity and attract tourists.

But scientists believe that Mexico will have other "corn field volcanos" rising out of the earth as dramatically as Paricutin. One authority, Dr. Fred M. Bullard of the University of Texas, has traced the development of Mexico's volcanos and says there will be more. His theory puts the appearance of the next one along about two centuries from now.

The Taxability of Minerals

September 7, 1949

The Earth Science Digest,
Revere, Massachusetts

Gentlemen:

The attention of the Bureau has been called to the fact that there appears to be some controversy regarding the taxability of mineral substances under section 2400 of the Internal Revenue Code.

The tax imposed under section 2400 of the Code attaches to the sale at retail of all precious or semi-precious stones regardless of whether they are real or imitations, cut or uncut , whether drilled, mounted or matched, and whether temporarily or permanently strung or whether with or without clasps.

It has been the consistent policy of the Bureau to hold that all varieties of stones used for ornamental purposes and having a Moh's scale hardness of six or more are precious or semi-precious stones within the meaning of the above-mentioned section of the Code. However, no tax attaches to the sale of mineral substances such as diamonds, rock crystals, garnets and hematite which are sold for research, educational or industrial purposes where no ornamental purpose is involved such as mineral hardness testing, polishing, cutting and grinding. The sale of such a stone for use as a display specimen in a museum or elsewhere is considered to be the sale at retail of the stone and is, therefore, subject to tax irrespective of whether it is cut or uncut.

Very truly yours,

CHARLES J. VALAER
Deputy Commissioner of
Internal Revenue
Treasury Department
Washington 25, D. C.

The BOOK SHELF

All books listed here may be obtained by sending a check or money order to THE BOOK SHELF, THE EARTH SCIENCE DIGEST, REVERE, MASS. We pay postage.

A CATALOG OF BOOKS ON THE EARTH SCIENCES

Part IV — Physical Geology

A MANUAL OF SEISMOLOGY by Charles Davison. 1921. 256 pp., illus. ..... $ 5.80
A TEXTBOOK OF GEOMORPHOLOGY by Phillip G. Worcester. 2nd Edition. 1948. 584 pp., 385 illus. 5.25
ARCHITECTURE OF THE EARTH by Reginald A. Daly. 1938. 211 pp., 152 illus. 3.00
BRUNNER FOCAL-DEPTH-TIME-DISTANCE CHART by G. J. Brunner and J. B. Macelwane. 12 pp.; Chart 36 by 37" 3.00
CAUSES OF CATASTROPHE by L. Don Leet. 1948. 232 pp., illus. 3.00
CLIMATIC ACCIDENTS IN LANDSCAPE MAKING by C. A. Cotton. 1948. 354 pp., 267 illus. 7.00
DER GESTEINMAGNETISMUS; SEINE BEZIEHUNGEN ZU DEN ERSCHEINUNGEN DES FERROMAGNETISMUS UND ZUM ERD-MAGNETISCHEN FELD by Hans Haalck. In German. 1942. 90 pp. 3.25
EARTH FEATURES AND THEIR MEANING by William H. Hobbs. 2nd Edition. 1931. 517 pp., illus. 5.60
EARTHQUAKES by Nicholas H. Heck. 1936. 234 pp., 88 illus. 3.50
EARTH'S GRANDEST RIVERS by Ferdinand C. Lane. 1949. 320 pp., illus. 3 50
ELEMENTS OF GEOLOGY, Part II. PHYSICAL by W. J. Miller, 2nd Edition. 1939 ..... 2.35
GEOMORPHOLOGY by C. A. Cotton. 4th Edition, Revised. 1947. 505 pp., 473 illus. 6.00
GEOMORPHOLOGY: SYSTEMATIC AND REGIONAL by O. D. von Engeln. 1942. 655 pp., illus. 6.00
GEOMORPHOLOGY: THE EVOLUTION OF LANDSCAPE by Norman E. A. Hinds. 1943. 903 pp., illus. 8.00
GLACIAL GEOLOGY AND THE PLEISTOCENE EPOCH by Richard F. Flint. 1947. 589 pp., illus. 6.00
GLACIAL STUDIES OF THE PLEISTOCENE OF NORTH AMERICA by William H. Hobbs. 1948. 109 pp., illus. 3.00
GROUND WATER by C. F. Tolman. 1937. 593 pp., 189 illus. 6.50
INTRODUCTION TO PHYSICAL GEOLOGY by W. J. Miller. 5th Edition. 1949 ..... 4.50
LANDSCAPE AS DEVELOPED BY THE PROCESSES OF NORMAL EROSION by C. A. Cotton. 1948. 509 pp., 375 illus. 10.00

Physical Geology (Cont.)

OCEANOGRAPHY FOR METEOROLOGISTS by H. U. Sverdrup. 1942. 250 pp., illus. 4.65

PHYSICAL GEOLOGY by Chester R. Longwell, Adolph Knopf, and Richard F. Flint. 3rd Edition. 1948. 602 pp., 365 illus. 5.00

OUTLINES OF PHYSICAL GEOLOGY by Chester R. Longwell, Adolph Knopf, and Richard F. Flint. 2nd Edition. 1941. 387 pp., 281 illus. 3.25

PHYSICAL GEOLOGY by William B. Scott. 3rd Edition. 604 pp., illus. 4.75

PHYSICAL GEOLOGY AND MAN by Kenneth K. Landes. 1948. 414 pp., 165 illus. 6.00

PRACTICAL SEISMOLOGY AND SEISMIC PROSPECTING by L. Don Leet. 1938. 465 pp., 185 illus. 6.00

PRINCIPLES OF STRUCTURAL GEOLOGY by Charles M. Nevin. 4th Edition. 1949. 410 pp., 250 illus. 6.00

SEISMOLOGY by Perry Byerly. 1942. 256 pp., illus. 4.65

SHORE PROCESSES AND SHORELINE DEVELOPMENT by Douglas W. Johnson. 1919. 584 pp. 8.00

STRENGTH AND STRUCTURE OF THE EARTH by Reginald A. Daly. 1940. 434 pp., illus. 5.00

STRUCTURAL GEOLOGY by Marland P. Billings. 1942. 484 pp., illus. 6.35

STRUCTURAL GEOLOGY by B. Stoces and C. H. White. 1935. 460 pp., 604 illus. 9.00

SUBMARINE GEOLOGY by Francis P. Shepard. 1948. 338 pp., 106 illus. 6.00

THE FALLS OF NIAGARA by Glenn C. Forrester. 1928. 155 pp., 42 illus. 2.50

THE NEW ENGLAND-ACADIAN SHORELINE by Douglas W. Johnson. 1925. 608 pp., 273 illus. 8.50

THE OCEAN by F. D. Ommaney. 1949. 238 pp., 16 illus. 2.00

THE OCEANS: THEIR PHYSICS, CHEMISTRY AND GENERAL BIOLOGY by H. U. Sverdrup, Martin W. Johnson, and Richard H. Fleming. 1942. 1097 pp., illus. 10.00

THE ORIGIN OF EARTHQUAKES by Charles Davidson. 1942. 144 pp., illus. 0.90

THE QUATERNARY ICE AGE by W. B. Wright. 1936. 2nd Edition. 478 pp., illus. 6.00

THE SURFACE HISTORY OF THE EARTH by John Joly. 2nd Edition. 1930. 234 pp., illus. 3.50

THE WORLD'S GREAT LAKES by Ferdinand C. Lane. 1947. 272 pp., illus. 3.50

Next month: Part V: HISTORICAL GEOLOGY;
Paleontology, Stratigraphy, Evolution, etc.

Part I (June 1949)—MINERALOGY, CRYSTALLOGRAPHY.

Part II (July 1949—GEMOLOGY, PETROLOGY, PETROGRAPHY, FLUORESCENCE, RADIOACTIVITY.

Part III (Aug. 1949)—GENERAL GEOLOGY. PHYSIOGRAPHY.

URANIUM DETECTION!!!

the famous **"SNIFFER"**

a precision GEIGER-MUELLER Counter

LOCATES RADIOACTIVE ORES!

$54.50

COMPLETE

The "SNIFFER" — a superb Geiger-Mueller Counter — is made by the leading manufacturer of high calibre radioactivity detection and measuring instruments for U. S. Government atomic research laboratories and for Universities engaged in Nuclear Research.

WIDELY USED BY AMATEUR PROSPECTORS, GEOLOGISTS AND LARGE MINING COMPANIES

The "SNIFFER" weighs approximately 2 lbs., Extremely sensitive, yet rugged . . . Gives very loud signals . . . Operates on two easily available and replaceable flashlight cells . . . Anyone can operate the "SNIFFER".

Mail Orders Promptly Filled From Stock.

Send Check or Money Order To:

The Radiac Co.

489 FIFTH AVENUE, DEPT. "E", NEW YORK 17, N. Y.